

COVID-19: A Review of the Effectiveness of Non-Pharmacological Interventions

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Abstract

COVID-19, a highly infectious disease, caused by a novel virus, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has brought about an unprecedented threat to global health. First reported in Wuhan, China, in December 2019, it has now spread to all continents of the world becoming a pandemic. There is no known treatment or vaccine for it although many candidate drugs and vaccines are in various clinical trial phases. For now, non-pharmacological interventions (NPIs) have become the mainstay of response for COVID-19 and are being used across the world to flatten the epidemiologic curve with some success. This review focussed on identifying which NPIs have been effective. NPIs that are effective include isolation and quarantine, physical distancing, use of face masks and hand hygiene. These measures are best used in combination and simultaneously. The evidence is that they should be instituted early in the pandemic and for sustained periods. They should also be implemented in the context of the cultural and socioeconomic conditions of the populace. Ineffective NPIs include ultraviolet irradiation and spraying of outdoor spaces and individuals. We recommend that decision makers weigh the evidence carefully, as it applies to the local setting to inform public health decisions.

Keywords: Coronavirus disease 2019, epidemic, non-pharmacological interventions, pandemic, severe acute respiratory syndrome coronavirus-2

INTRODUCTION

The COVID-19 pandemic is unprecedented in the magnitude and severity of the disruption it has caused in virtually all aspects of human life worldwide. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the aetiological agent for COVID-19. A condition that was only first identified in December 2019 and now has over 17,396,943 reported cases worldwide as of 1 August 2020.^[1] In Nigeria, 43,537 cases have been reported as of 1 August 2020.^[2] Believed to have started in Wuhan, China, the social global interconnectedness eased the spread of the disease worldwide and the often late and/or inadequate response.^[3]

The disease is spread by three main modes of transmission: direct or indirect contact transmission, respiratory droplet transmission and aerosol transmission. Direct contact transmission involves direct contact with an infected person,

for example through a handshake. Indirect contact involves touching a contaminated inanimate object. Droplets containing the virus may project for a distance for up to 2 m when an infected person sneezes, coughs or talks. Aerosolised droplets remain suspended in the air for long periods and may travel farther distances.^[4]

The incubation period of COVID-19 is 2–14 days. The range of symptoms that are non-specific includes fever, dry cough, rhinorrhoea, chest pain, difficulty in breathing, sore throat, diarrhoea, anosmia, ageusia, myalgia and arrhythmias. The elderly and those with other underlying illnesses, which include hypertension, diabetes mellitus and chronic obstructive airway disease, or those who are immuno-compromised are particularly at risk.^[5,6] Pre-symptomatic transmission occurs

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when an infected person sheds the virus up to 5 days before developing symptoms. On the other hand, asymptomatic direct transmission occurs when a person who never develops symptoms infects another person. The potential for environmental transmission also exists from reports that the virus may survive for up to 3 days on inanimate objects.^[7,8] The virus has also been detected in stool.^[9] In China, more than 80% of the patients among the first 72,000 cases had mild disease. Although the overall case fatality rate was 2.3%, this increased to 8% and 14.8% in the 70–79 and above 80 age-group respectively.^[10] In Nigeria, 75% of the first 32 cases had illness of moderate severity and a median hospital stay of 12 days (interquartile range: 9–13.5).^[11]

Suppression and mitigation are two main strategies that have been used by different countries and their outbreak response teams towards controlling COVID-19 within their jurisdictions.^[12] The suppression strategy aims to halt the outbreak through aggressive state or countrywide lockdowns. This works best in the early stages and in the absence of community transmission. The basic reproductive number (R_0) is kept at <1 , that is, each case transmits the disease to no more than 1 person. Mitigation aims to manage the outbreak such that the pandemic does not overwhelm the country's health system. This strategy allows the development of herd immunity, potentially reducing the likelihood of a second wave of the pandemic or its severity if it does occur. In this case, the interventions are mainly targeted at vulnerable populations such as the elderly and those with pre-existing morbidities.

In the absence of effective treatment or vaccines for COVID-19, non-pharmacological interventions (NPIs) become the mainstay of response to controlling the pandemic. NPIs could be targeted at having global-, national- or individual-level benefits. Closure of international borders and points of entry/exit, as well as screening of travellers, helps to control international spread. School closures, modified work arrangements and isolating patients, all help in reducing spread in the community. Furthermore, hand hygiene, use of face masks and other personal protective equipment provide individual-level protection. Several NPIs are being used, but the evidence for their effectiveness is often not available. Therefore, the objective of this review is to describe the effectiveness of the different NPIs which have been used in the on-going COVID-19 pandemic.

HISTORICAL USE OF NON-PHARMACOLOGICAL INTERVENTIONS

NPIs have been used in the past to deal with pandemics such as the plague and the 1918 influenza pandemic. Quarantine is derived from the Italian word *quaranta*, meaning '40'. The concept of quarantine began in the 14th century after outbreaks of the plague. Following the devastation caused by the disease, authorities decided that any person thought to have contracted the disease be taken out of the city to prevent

them from infecting others.^[13,14] The first formal quarantine facility was built on an island in Venice in 1423.^[15] It was also used when ships arriving at the port of Venice from foreign travels were made to wait 40 days to disembark to allow time for any person infected with an infectious disease to manifest symptoms and thus be identified. The use of these measures helped in controlling the disease.^[16]

A little over a hundred years ago, in 1918, the world experienced an influenza pandemic which is now known as the 'Spanish flu'. The H1N1 was a novel virus at that time for which there was no treatment, vaccine or understanding of its pathophysiology. The disease accompanied troop movements across the world and in the end, the pandemic ultimately led to the death of 50–100 million people across Asia, Europe, Africa and the Americas. The main control measures were NPIs such as surveillance, quarantine and isolation. In the USA, the most common NPIs used were school closures and ban on public gatherings. Cities that introduced NPIs earlier had: greater delays to reach peak mortality, lower peak mortality and lower total mortality.^[17]

EFFECTIVENESS OF CURRENTLY USED NON-PHARMACOLOGICAL INTERVENTIONS

NPIs recommended by the World Health Organization (WHO) for use in influenza pandemics at any level of severity include hand hygiene, face masks for symptomatic and asymptomatic individuals, isolation of sick individuals, travel advice, surface and object cleaning.^[18] When the severity is high, the use of Face masks by the public and school closures are recommended as additional measures. When the severity is categorised as extra-ordinary, internal travel restrictions and workplace closures are further measures.

A study from Wuhan, China, found that a combination of NPIs including social distancing, quarantine, traffic restriction and universal symptom survey were temporally associated with the control of COVID-19.^[19] Another study in China predicted that without the use of NPIs, the COVID-19 outbreak would have had a 67-fold increase in the number of cases.^[20] A report from Europe on the effects of NPIs in Europe estimated that they were able to prevent over 3 million deaths from COVID-19 across 11 countries on the continent.^[21] This is supported by another modelling study that compared 16 countries around the world. Assuming a baseline R_0 of 2.2, the report estimated that intermittent cycles of mitigation and relaxation reduced the R_0 to 0.8, while intermittent suppression and mitigation reduced the R_0 to 0.5.^[22] In the UK, a modelling study showed that school closures, physical distancing, shielding of at-risk persons and self-isolation were all likely to decrease the R_0 but not sufficiently to prevent intensive care unit demand from existing health services.^[23] A limitation of modelling studies is that they are unable to capture all the transmission dynamics of the infection as they are predicated on fixed constants for the production of the results.

LOCKDOWN

A lockdown is a community-wide containment strategy implemented to reduce person-to-person interaction to a minimum. It involves the shutdown of government offices, businesses, schools, social and recreational facilities and transportation services but exempting essential services such as health, security and basic utilities. This drastic NPI only becomes necessary to forestall or slow community transmission. Hubei province in China was the first to implement this starting with Wuhan before extending to the whole of the province, thereby affecting more than 60 million residents in over twenty cities.^[24] The use of sub-national or national lockdowns were also implemented in other countries around the world including Nigeria. Lockdowns are enforced through the use of public health laws as have been enacted in Nigeria^[25] and Lagos State.^[26] To evaluate the effects of the lockdown in China, a group of researchers compared the growth curves of cases and correlated these with domestic air traffic. Their evaluation was based on data derived from publicly available COVID-19 situation reports. In the immediate period following the implementation of the lockdown, there was a significant increase in doubling time of COVID-19 cases from 2 days (95% confidence interval [CI]; 1.4–2.6) to 4 days (95% CI: 3.5–4.3).^[27] In Nigeria, the initial lockdown limited to Lagos, and Ogun State and Abuja, the Federal Capital Territory had limited impact as the country had since moved into community transmission. Perhaps, a total country-wide lockdown may have been more beneficial. Lockdowns bring about compulsory physical distancing but at a great economic cost. Thus, citizens may not obey as socioeconomic hardship and hunger set in. This makes it difficult to achieve compliance and prevent the spread of the infection.

AIRPORT CLOSURE/TRAVEL RESTRICTIONS

The ease of international travel is thought to have facilitated the spread of the disease across the world and consequently the pandemic. Some authors reported that in <2 months after the outbreak in China, international flights had contributed to exporting the diseases to not <26 countries.^[28] Besides, another described a linear relationship between the number of cases and local air passenger traffic within China ($r^2 = 0.92$; $P < 0.19$) as well as international air travel ($r^2 = 0.98$; $P < 0.01$), further confirming the role of international flights.^[27] In response to the export of cases from China, many countries closed their external borders for the first time.^[29] Using daily COVID-19 incidence data and global airport network connectivity, some researchers found that travel restrictions enforced by China averted 70% of cases that would have been exported and in the first 3 weeks of implementation, the daily rate of exported cases dropped by 81%.^[27] However, the impact of the measures was limited to the early phase of the pandemic and underreporting was a limitation of the study.^[27] The travel restrictions in Wuhan implemented along with a lockdown is estimated to have slowed the progression of the pandemic in other parts

of China by 3–5 days.^[30] Another report estimated that the introduction of travel control measures in Wuhan, China, reduced the median daily R_0 from 2.35 to 1.05.^[31] In Europe, modelling studies on the spread of infection in the absence of travel restrictions have shown that the pandemic would have spread at a much faster rate with the consequent impact on the health systems of countries all over the world.^[32] Airport closures alone will not work except to restrict potential carriers from importing it to destination countries. Physical screening done at airports is unlikely to help as only the very sick may manifest symptoms with a resultant low yield. It is estimated that up to 64% of infected persons who are travelling are known to be pre-symptomatic.^[27] A voluntary form of travel restriction given to the public is to avoid non-essential travel, although widely used globally the effect on the pandemic is uncertain.

PHYSICAL DISTANCING

Physical distancing is the maintenance of space between self and persons outside one's household. This is achieved by avoiding groups, large gatherings and maintaining a distance of 2 m from other people to reduce the risk of direct transmission of COVID-19. The size of groups or gatherings is determined by individual countries based on their local situations. These rules must be applied consistently and without bias to maintain the trust of the public and thus, compliance. A meta-analysis investigating the level of protection conferred by various interventions in use reported that physical distancing of at least 1 metre independently reduced the risk of virus transmission (adjusted odds ratio 0.18; 95% CI: 0.09–0.38).^[33] A systematic review of workplace physical distancing found the policy reduced the influenza attack rate by 23% in the general population.^[34] Workplace physical distancing is being used by both public and private sectors in Nigeria in the form of work from home or limiting the numbers that report physically to the office but its effectiveness is unknown. Given the effectiveness of physical distancing, it is important to consider its implementation. For instance, a modelling study reported that single interventions of physical distancing were not very effective as resurgence of cases were likely to occur once distancing was removed.^[35]

QUARANTINE AND ISOLATION

Quarantine means the separation and restriction of movement of people who have potentially been exposed to a contagious disease to ascertain if they become unwell, thereby reducing the risk of transmitting it to others. Quarantine could be voluntary or made mandatory using relevant public health laws.^[25,26] It is most effective when there is an effective system for contact tracing and early detection of cases.^[24] Any quarantine plan will need to also include considerations for providing necessities such as feeding and household supplies to the quarantined and where resources are available, compensation for lost earnings due to absence from work. A closely related but different term is isolation which refers to the deliberate separation and confinement of a person who is known to have

a contagious disease.^[36] Isolation is effective for infectious diseases that can be promptly detected and in which there is a high person-to-person transmission. In Nigeria, isolation centres have been established in every state to care for the sick. Contact tracing is the prompt identification of individuals that have been exposed to a confirmed case of a disease. As an NPI measure, it helps in informing quick preventive measures and early identification of cases, thus reducing the spread of the disease.

In the context of the COVID-19 pandemic, the WHO recommends that close contacts of persons with confirmed COVID-19 infection should be quarantined for 14 days counting from the most recent time of exposure to the confirmed case. Quarantine facilities would preferably be well-ventilated single rooms with normal furnishings and equipment for day-to-day life.^[37] Hotels, school dormitories, religious camps and such similar settings could easily be adapted for this purpose. Home quarantine is effective if the above conditions can be met. In addition, there will be need to avoid shared spaces and keep a distance of a minimum of 1 m from other household members. Those under quarantine should be monitored for the development of symptoms so that early management can be instituted. Persons being quarantined and the persons caring for them should be well trained in infection, prevention and control measures and proper and regular disinfection of the quarantine environment should be carried out. Some authors have suggested that about 70% of cases have to be traced successfully to contain the outbreak of COVID-19 assuming a R_0 of 2.5.^[38] A systematic review on the effects of quarantine, on COVID-19 and other recent pandemics such as SARS and Middle East Respiratory Syndrome, which included modelling and observational studies reported that quarantine alone could reduce the incidence of new cases by 44–81 percentage points, as well as reduce mortality by between 31 and 63 percentage points.^[39] Greater benefits are expected if quarantine is combined with other measures as often happens in practice.

However, quarantines and isolations have some negative consequences which also have to be carefully managed. The negative consequences arise from the loss of freedom and disruption of routine life. Surveys conducted among people that had to quarantine found a high prevalence of mental health disorders such as exhaustion, depression, irritability and insomnia among others.^[40,41] In Nigeria, effective use of quarantine may be difficult in many communities where sub-standard housing exists and facilities such as separate bathrooms are scarce. Public information management in the form of clear and transparent updates and guidelines on the implementation of isolation and quarantine is also important to encourage compliance and avoid panic by members of the public.

SCHOOL CLOSURES

Closure of schools is an important NPI as schools serve as an

ideal setting for rapid transmission of the infection. Young children may not be compliant with the use of NPIs and maintaining physical distancing presents a unique challenge both in the classroom and on the playground. School closures reduce the likelihood of transmission between pupils and between school staff and pupils. This probably explains why many countries including Nigeria are not as quick to reopen schools. School closure also forces parents and caregivers to stay home, thus reducing work exposure for the parents too. However, most studies have evaluated school closures as part of other interventions and not as a single measure. A systematic review of over 100 studies in the UK found that the benefit of school closure was conditional upon low transmissibility $R_0 < 2$ of the disease and also children must have a higher attack rate than adults.^[42] A modelling study estimated that school closure was more effective if the R_0 was < 1.5 and was best with other NPIs that reduced contact with infected persons.^[43]

School closure in an epidemic of SARS which had a low prevalence and attack rate among children is reported to have contributed little to controlling the outbreak.^[44] The evidence from a more recent review was more categorical. The reviewers found that school closure and social distancing prevented transmission of disease in school-aged children would prevent only 2%–4% of deaths and was not as effective as other social distancing measures.^[45] The negative effects of school closure though, are the missed educational opportunities and impact on educational outcomes. Besides, school is a safe place away from domestic abuse which may increase during school closures. Health interventions delivered through schools, such as school meals, are also missed out. There remain questions on the timing of the closure of schools during the pandemic and when it is safe to reopen. Care must be taken in reopening schools as the exposure to infection is likely to be high from other children who may be asymptomatic, school staff and parents/guardians, who come to the school premises and classes.

PERSONAL PROTECTIVE NON-PHARMACOLOGICAL INTERVENTIONS

Various hygiene measures stemming from the principles of infection prevention and control and also studies on the effect on the individual measures on other diseases can be implemented. Frequent hand washing with soap or alternatively an alcohol-based hand rub can be used. Also, the use of respiratory etiquette by coughing into tissues or the bent elbow rather than the palms of the hands is important and should continue to be promoted. It potentially prevents the shedding of the virus into the environment.

HAND HYGIENE

Hand hygiene is one of the key measures promoted by the WHO and other health experts towards containing COVID-19 disease. This is because hand washing has been shown to reduce hand contamination with disease-causing

microorganisms by up to 90% and respiratory illnesses in general by a fifth.^[46] Frequent, thorough and rigorous hand washing with soap and running water for at least 20 s is recommended to be promoted at the community level. In the absence of soap or if the hands are not visibly soiled, an alcohol-based hand sanitizer could be used. The hand sanitizers should have at least 60% alcohol content.^[47] The efficacy of hand wiping with various cleansing agents was tested by some researchers in China. Having deliberately contaminated the hands of one of the authors, with laboratory propagated, low pathogenic avian influenza virus they proceeded to wipe the hands with a towel soaked in water containing 1% soap powder, 0.05% active chlorine from sodium hypochlorite and 0.25% active chlorine from sodium hypochlorite. Wiping the hands with these solutions reduced the viral contamination by 98%, 96% and 99%, respectively.^[48] A group of researchers conducted a cluster-randomised intervention of face mask and hand hygiene in young adults ($n = 1178$) before and during the onset of an influenza epidemic. They reported a 75% reduction in influenza transmission in the groups that used had hygiene and face masks combined compared to the control group.^[49] Hand washing is a simple low-cost NPI and is highly recommended. One challenge faced by communities in Nigeria is the availability of clean water which at times has to be purchased. Hand hygiene is also important in healthcare settings to prevent nosocomial transmission of the disease.^[50] In clinical settings, the moments for hand hygiene are before touching a patient, before clean or aseptic procedures, after body fluid exposure, after touching a patient and after leaving a patient's surrounding.^[51] Despite the clear recommendations, adherence to hand hygiene has been found to be low among healthcare workers for reasons which include the absence of hand washing stations or non-availability of alcohol-based hand rubs.^[52] Health workers should continuously be reminded about the five moments of hand hygiene in the workplace through training, strategic placement of information, education and communication materials, and other innovative means. A concern with frequent hand washing among health workers who by nature of their continuous exposure to potentially contaminated body fluids and surfaces need to wash their hands very often is the development of skin disorders such as eczema or macerations. This was reported by a study among a group of healthcare workers, who reported washing their hands at least 10 times daily, three-quarters of them reported damage to the skin of the hands although the use of self-reports is a limitation of the study.^[53]

FACE MASKS

Across the world, at the start of the pandemic, there was no clear policy on the use of face masks and use in community settings was even discouraged.^[54] The correct and consistent use of face masks has now become one of the interventions to control COVID-19. Without compliance with other protective measures, a mask offers limited protection against the disease. The WHO has recently published a guide for the use of face

masks in the context of the COVID-19 pandemic for public use and also in healthcare settings.^[55] In community settings, the first consideration should be maintaining physical distancing. However, where physical distancing of 1 to 2 m from other people cannot be maintained, it is recommended that any type of mask should be used. The masks serve as a form of source control in infected persons. Mask use is a form of the citizenry taking responsibility for their health during the pandemic. Face masks are recommended where physical distancing cannot be achieved such as in public transportation (bus, plane or train) and in specific work conditions that place the employee in close contact with others.^[55]

The use of any type of face covering is described as causing a significant reduction in the risk of contracting respiratory viruses. One study reported an adjusted odds ratio of 0.15, 95% CI of 0.07–0.34 with the use of face masks and showed stronger associations with N95 masks or similar respirators.^[33] Using a machine simulation of human breathing of contaminated air, it was reported that N-95 and medical masks were able to block almost 100% and 97% of viruses, respectively, while a multi-layered home-made mask (consisting of four layers of kitchen paper and one layer of polyester) was effective in blocking 97% of viruses.^[48] A prospective, randomised trial to compare the efficacy of cloth masks, medical masks and control group, which used both medical and cloth mask (standard practice) on clinical respiratory illness and laboratory-confirmed respiratory illness among health care workers ($n = 1607$) in high-risk wards of secondary/tertiary level hospitals in Hanoi, found that the risk of influenza-like illness (ILI) was significantly highest in the group that used cloth masks (relative risk RR = 13.25, 95% CI: 1.74–100.97) compared to the group that used medical masks. The risk of ILI was also higher in the cloth mask group compared to the control group (RR = 3.49, 95% CI: 1.00–12.17).^[56] A strength of the study was its large sample size and it provided evidence that the use of cloth masks could be harmful in the health care setting.^[56]

In healthcare settings, fabric masks are not suitable.^[56] Medical masks, also known as surgical masks or procedure masks and respirators such as the N95 respirator, are either used using a universal masking strategy or a targeted continuous medical mask use. Universal masking means that all health workers and visitors are required to wear masks within the hospital premises. Targeted continuous mask-wearing means that masks should be worn by all persons in clinical areas at all times. Where available, N95 respirators are recommended for use when providing care to COVID-19 patients and when not freely available they should be used during aerosol-generating procedures.

INEFFECTIVE NON-PHARMACOLOGICAL INTERVENTIONS

There are some NPIs that are sometimes considered, but there is either a lack of evidence to support their use or concrete evidence that they do not work. For example, ultraviolet

irradiation is used for disinfection, but they are relatively expensive to install and thus, not applicable to wide settings and for large populations.^[18] In addition, if a surface is covered, penetration will be limited. Manipulation of humidity is another intervention that has no supporting evidence but rather increasing humidification may increase indoor dampness and mould and thus aggravate asthma.^[57]

Spraying of outside spaces such as streets or market places is not recommended as the disinfectant is inactivated by dirt and cannot have enough contact time to kill the pathogen. Even though spraying public places may be impressive to the public, its lack of effectiveness is not in doubt. Besides, spraying individuals with disinfectants is not recommended under any circumstances as it will not only harm the physical and psychological health of the person and will not reduce the transmission of the virus from infected persons.^[58]

CONCLUSION

The WHO Ebola Response Team in their special report on the West African EVD outbreak of 2014 rightly stated that ‘for managing future Ebola outbreaks, community engagement, early case detections and diagnosis, comprehensive contact tracing, prompt patient isolation, supportive clinical care, rigorous infection control and safe burials are key’.^[59] This is also true of the COVID-19 pandemic.

A combination of NPIs should be implemented consistently and long enough to gain maximum effect and be eased gradually being guided by accurate pandemic data. Key NPIs in Nigeria include hand washing, face masks and physical distancing. They require intense and sustained communication to ensure high compliance. Policymakers should use scientific evidence to guide the deployment of NPIs and contextualise them within the socio-cultural and economic situations of their countries. The pandemic must not be treated as a purely medical problem but issues of livelihood must be considered in the use of NPIs. Government palliative measures should be widely distributed to those in need the most as this will build public trust and make compliance much easier.

Compliance with the NPIs by the citizenry is critical to their effectiveness. A study showed that fear of COVID-19 was the only predictor of desired behavioural change and compliance with NPIs.^[60] The health belief model may then be applied to drive home key messages and ensure compliance. At the minimum, the public should receive full, transparent information presented in simple and clear terms and the rationale behind the various measures being implemented in the various local languages.

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